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AN UNDERWATER ULTRASONIC TRACKING DEVICE

MUHAMMAD ASYRAF BIN BAHARUDDIN

A final year project report submitted inpartialfulfilment of the
requirements for the award of the degree of
Bachelor of Engineering (Electrical – Instrumentation and Control)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2015

I declare that this final year project report entitled "*an underwater ultrasonic tracking device*" is the result of my own research except as cited in the references. The final year project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Special dedicated for my parents, siblings and friends

Thanks for being supporting and encouragement

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ABSTRACT

Various industries require a precise, linear indication of the depth of water in a specific part of the water. This demands a continuous level measurement. Ultrasonic detectors can measures the distance between theseabed to the surface of the water. To measure level and depth, with an ultrasonic range detector, the module is mounted at the bottom of the sea in example, the seabed, looking up the surface. We must measure the time between the transmit pulse and the echo received pulses. Since the ultrasonic signal is travelling at the speed of sound, the time between transmission and echo received is a measure of the distance to the surface, water depth. The underwater ultrasonic tracking device here is focused on low cost material. It is used to search an object under the water. The sensor only transmitted to the large size of area. As a conclusion, it can detect within a range of 7cm.

ABSTRAK

Pelbagai industry memerlukan, petunjuk linear tepat kedalam air di bahagian tertentu dalam air. Ini memerlukan ukuran tahap yang berterusan. Pengesan ultrasonic boleh mengukur antara permukaan dasar air ke permukaan air. Untuk mengukur tahap dan kedalamannya, dengan pelbagai pengesan ultrasonic yang ada, modul dipasang di bahagian bawah laut. Sebagai contoh, dasar laut, dilihat ke atas permukaan air. Kita mesti mengukur masa antara denyutan penghantar dan gema menerima denyutan. Selepas isyarat ultrasonic bergerak dengan kelajuan bunyi, masa antara penghantaran dan echo diterima adalah ukuran jarak ke permukaan iaitu kedalaman air. Peranti pengesan ultrasonic dalam air pada projek ini member tumpuan kepada bahan kos rendah. Ia digunakan untuk mencari objek di bawah air. Sensor hanya dihantar kepada saiz besar kawasan. Kesimpulannya, ia boleh mengesan dalam pelbagai 7cm.

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LIST OF ABBREVIATIONS

AC	Alternating Current
AVR	Advanced Virtual RISC
DC	Direct Current
EEPROM	Electricity Erasable Programmable Read-Only Memory
I/O	Input / Output
IDE	Integrated Development Environment
LED	Light Emitting Diode
PDE	Processing Development Environment
PWM	Pulse Width Modulation
RC	Radio Control
SRAM	Static Random-Access Memory
USB	Universal Serial Bus

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CHAPTER 1

INTRODUCTION

1.1 Background

Ultrasonic sensor has been applied since 1917 by Paul Langevin while he was trying to emit sound waves in the sea water. He is also known as the father of ultrasonic[1]. Nowadays, the developing of science for sound wave has been implemented in various applications. The system can be applied for the sound communication of submarines, measuring depth of sea, level of the tank or some more. Ultrasound is also widely used in physical check up or investigations. In industry, ultrasonic is used for cleaning, emulsifying or else. In biological, the ultrasonic used for killing bacteria.

The term ultrasonic refers to the frequency of sound above 20 kHz. Basically, the usage of ultrasonic in medical can be extended more than 10 MHz. For the animals such as bat vision, dolphins or else commonly use a range of frequency around 20 to 100 kHz. Commonly, the high frequency usage about 1 to 20 MHz used in medical treatment. For any industries application, there are only use near to 20 kHz[2].

As stated above, the demanding of ultrasonic become increasing in many type of industry. So the performance of ultrasonic can be different depends on the characteristic, operating, specification and action taken by each industry. The ultrasonic also had been increase their capability which is it is being use for navigation or collision avoidance application[3]. For instrumentation application, it

is suitable to build up a measuring ultrasonic sensor such as finding or locating an object. Nowadays, the underwater application also has been developed. The usage of ultrasonic in the water can be seen through naval application such as communication system, detecting object or else.

1.2 Problem Statement

In some cases, a suffocated person or object cannot be found because the body object is carried away by the swift water or muddy water. For a few moments, the dead bodies will start to sink to the bottom of a river or the sea. It will become more difficult to search the dead body because there is no exactly coordination of the dead body. It might take some times to search only one person in one time. To remedy this condition, an underwater ultrasonic tracking device that uses an ultrasonic has been developed.

Nowadays, there are a lot of ultrasonic sensor device invented but the usage of ultrasonic depends on the characteristic or requirement of the application itself. This is because not all the ultrasonic sensor has the same frequencies. For example, the speed of sound in air is around 340 m/s while the speed in water is 1500 m/s. By looking at the differences of medium, the ultrasonic sensor must be able to measure the distance inside the water. From those characteristics, the ultrasound sensor can be provided based on the desired specification of the transducer.

1.3 Objective

The main objective is to view the surface area underwater below 1m range. The other objectives are as follows:

- To assist the authority in searches an object inside the water.
- To be used in a shallow water area.
- To display the position of an object in the water by using a processing software.

1.4 Scope of Project

There are several of project's scope that can be implemented. The scope is includes:

- Using Arduino UNO and processing.
- Using ultrasonic sensor (HC-SR04) to send and receive signal by immersing underwater.
- Using servo motor to keep rotating the sensor by 45° until 135°.

1.5 Organization of the Thesis

The thesis contains of an Introduction, Literature Review, Methodology, Result and Discussion, Conclusion and lastly Project management.

Chapter 1 will be discussed about the problem statement, objectives and scope of the project. Chapter 2 will be discussed the literature reviews. Chapter 3 will be discussed about the methodology. Chapter 4 will be discussed about the results and discussion. Chapter 5 will be discussedabout the conclusion and recommendation. Lastly, chapter 6 will be discussed about project management.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review the relevant literature onunderwater ultrasonic tracking.

2.2 Underwater Ultrasonic Tracking System

Underwater ultrasonic tracking device is one of the technologies used to detect an object in the water. Nowadays, there are a lot of underwater tracking device invented. Mostly, the price is very expensive. There are a few techniques of underwater ultrasonic sensor application:

a) Underwater imaging system using acoustic holography

This type of system was developed to view some objects in muddy water. The development is focus on to get the image by inventing remote-controlled underwater machines. The image is not very clear because of the color of water itself. This is because the light has been burst and spreading. The system's ability is it able to show the real time 3D images. Other than that, the image can be calibrated by mean of single receiving or transmitting process[4].

b) Underwater Object recognition technique using ultrasonic

The system is about the multifunction development where it is the combination of an acoustic lens, multiple transmitters and a distributed receiver. To get the view of image, this technique use the camera with a frequency of 1 MHz and this technique can measure size and position of the object as well. The development is based on the differential frequency modulation technique which is related to the frequency domain analysis[5].

c) Detection and Tracking of Underwater Object based on Forward-Scan Sonar

The system is about the development of forward-scan sonar. The system has its own specification which is it is use the Gabor filter. As additional information, image produced by sonar are low contrast and high noise. So, Gabor filter technique can be used for detecting and tracking object underwater clearly by using Kalman filter as extracting method[6].

2.3 Ultrasonic Sensor

Ultrasonic sensor is a transducer which is has both transmitter and receiver to emit and receive signal. The concept of principle ultrasonic sensor is same alike sonar or radar where it spreading a signal to the target by interpreting the echoes. There are two types of ultrasonic sensor which active and passive ultrasonic sensor. The active ultrasonic sensor will generate high frequency and measure the echo bounces back by the sensor. The measurement also involving the time interval of the transmission and receiving the echo from the object to get know the distance. While the passive ultrasonic sensor, the ultrasonic sound will be detected by a microphone under a certain conditions.

.

The ultrasonic sensor can be used for measuring position of the object, the distance of the object, the level of tank or channel and also speed of wind. As additional information, to measure distance or level or speed, the time interval

between transmitter and echo must be calculate. Another application of ultrasonic sensor includes sonar, non-destructive testing and radar. Those are the type of application focus on industry. For medical, it is suitable to make an ultrasonography as an alternative way in medication technology.

Ultrasonic sensor or known as transducer basically generating a sound wave with a range of frequency above 18 kHz by converting electrical energy to the sound wave and then the echo signal will converted the sound waves to the electrical so that it can be measured and displayed by the sensor device.

The technology of ultrasonic sensor is quite limited depends on the density or shape or the material itself. For example, foam on the top of water surface can affect the reading of level sensor itself.

2.3.1 Velocity of Ultrasound and Wavelength

The velocity of ultrasound, c is formulated at a given temperature and a constant pressure. The relationship between T, f, c and λ is given by Equation (1) and (2). The Figure 2.1 below are the given formula [7]:

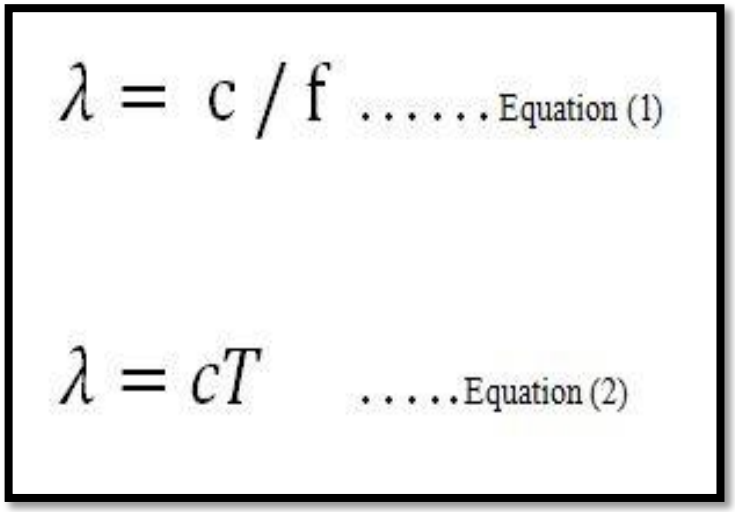


Figure 2.1: The formula of wavelength

Where

c = Material sound velocity

λ = Wavelength

T = Period of time

f = frequency

2.3.2 Wave Propagation

In many aspects, ultrasound is one the waves that can be found in the wave spectrum such as microwave and it is very similar to light or other magnetic waves form. The frequency of each type is different based on the propagation of waves in different type of medium. The velocity also changed depends on the type of medium. The concept of ultrasonic is same as light. It can be seen and refracted while going through each medium to another medium. So, this will be effect the speed of sound and refracted around a barrier. The energy also spreading just like a particles or dust scattered below a light[8].

Ultrasound is a type of mechanical energy. It vibrates and can be penetrate into any type of barrier such as liquid, gas and solid as well. Because of the similarities characteristic between light and electromagnetic waves, they are just same[9].

Basically, there are heats losses happen in the air. This is because the energy is absorbed by the air and there is many factor that will give an effect to the losses of heat such as molecular vibration modes, air viscosity heat conduction and composition of air[10].

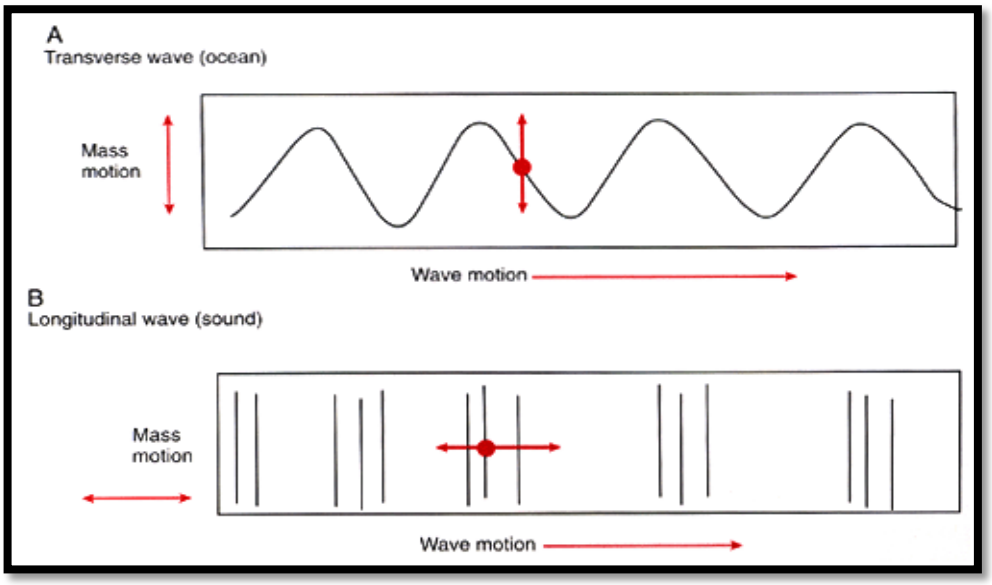


Figure 1.2: Illustration of the particle motion versus the direction of wave

2.3.3 Speed of sound waves in air and water

There are different medium in this world which are solid, liquid and gas. So, the velocity of sound is depends on each medium that it pass through. For example, the velocity of sound is different between air and liquid but in term of speed, the velocity of sound wave in water is faster than in air.

There are several factors that affect the velocity of sound which is the temperature, pressure and the salinity. For example, the ultrasound waves was disturbing by a particles of the high salinity of the sea water which is the particles is quite scattered and sometimes absorb or reflect the sound waves.

The case of sea water because of the wavelength and the frequency of sound waves are inversely proportional to the characteristic of ultrasound waves. The fact is the lower the frequency signals, the longer the sound wavelength based on the formula speed of sound as stated before. As a conclusion, a lower frequency can travel long distance away without any losses of signals strength. For example, ultrasound waves used for naval communication systems. It is developed by using a low frequency and long wavelength so that it can be enhanced the communication while submerging submarines[11].

CHAPTER 3

METHODOLOGY

Chapter 3 describes the methodology of the projectbeginning with the hardware implementationfollowed by software system development ultrasonic tracking device.

3.1 Project Overview

The construction of an underwater ultrasonic tracking device consists of two parts, which are hardware design and software design. Hardware design consists of servo motor, Arduino UNO, HC-SR04 ultrasonic sensor, bread board and housing. The ultrasonic sensor is used to detect or find out an object and send the signal back to the receiver. Lastly, the object's position will be display by a processing display window. Then, the servo will be rotate to detect an object within a limited range. By using this technique, display window can display an object's positioned as long as the object between the ranges of ultrasonic.

Software design is implemented by using an Arduino IDE and processing development environment (PDE) software which are designed by using C programming and C++ programming.

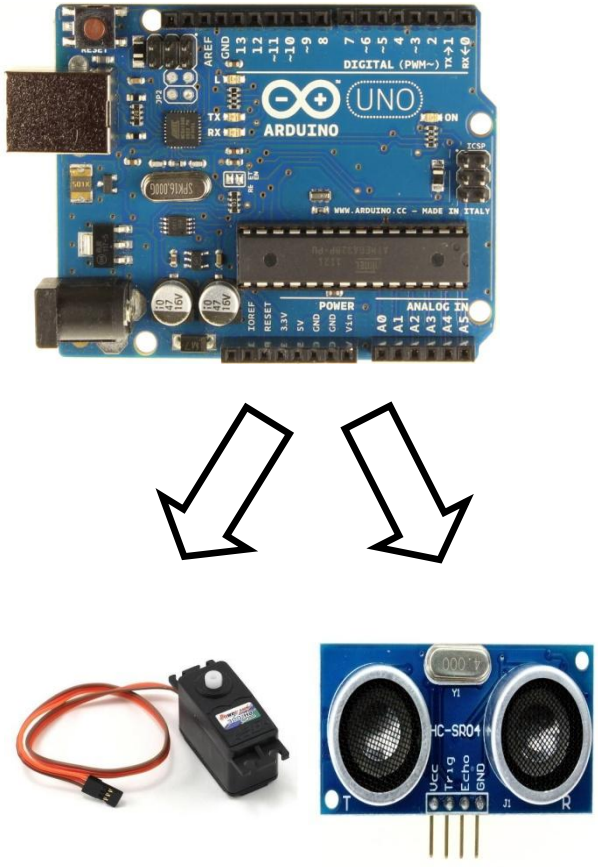


Figure 3.1: Overall design flow of underwater ultrasonic tracking device

The Figure 3.1 shows that the overall design of the system. The input of the systemconsists of signal from ultrasonic sensor. The servo motor will rotate 45° until 135°. The result of object position will be display at the processing display window.

3.2 Project workflow

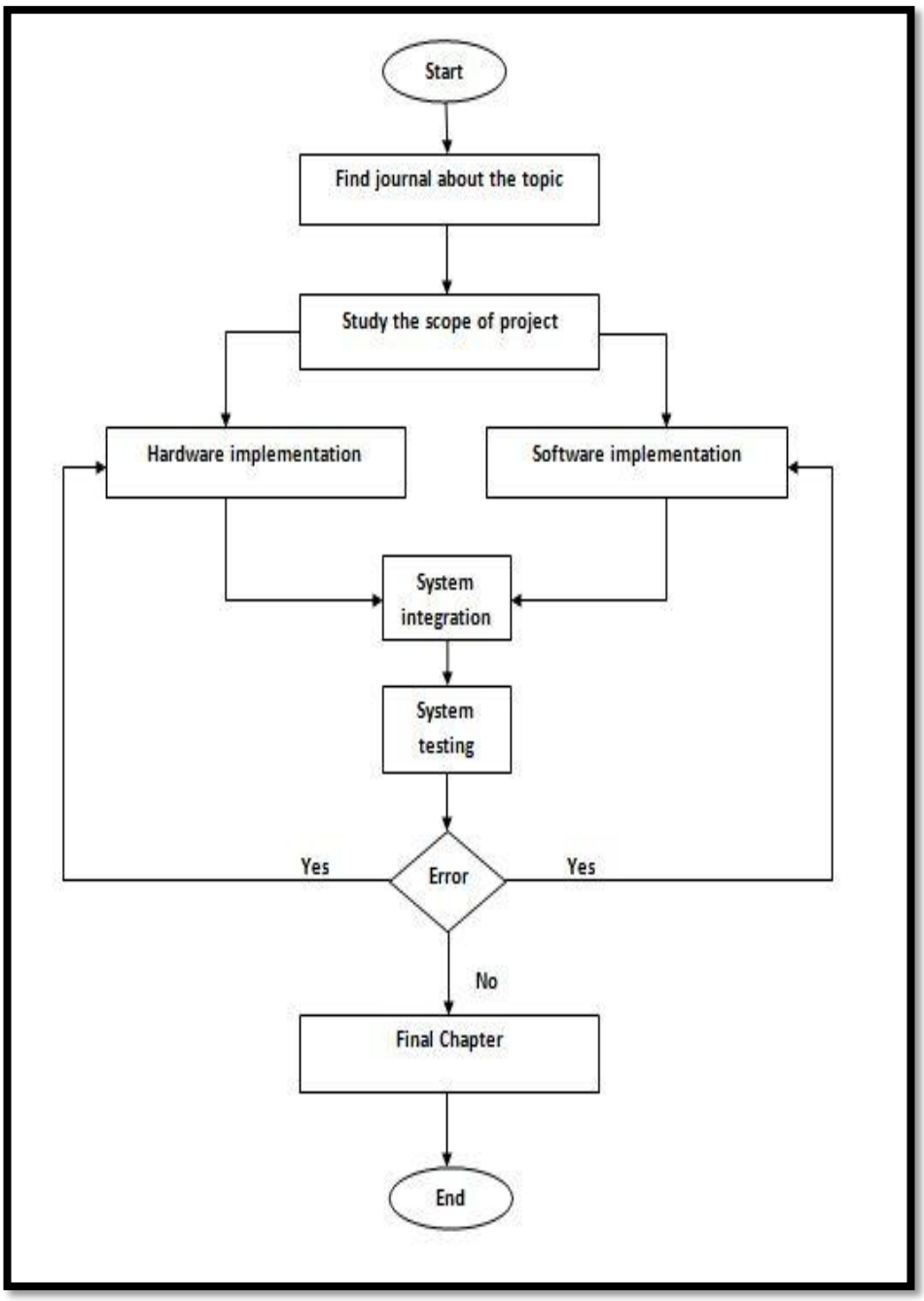


Figure 3.2: Flowchart of project flow

3.3 Underwater ultrasonic tracking device

An underwater ultrasonic tracking device is similar to other underwater ultrasonic device development in the market. Hardware and software is two parts that need to be done in this tracking device project. The hardware development is focus on the component used which is the designation of circuit and the underwater ultrasonic tracking device shape / casing. The software development is based on how to coding the programming of ultrasonic sensor which is Arduino IDE and processing PDE.

3.4 Hardware development

The hardware consists of the ultrasonic sensor, the Arduino UNO microprocessor, servo sensor and ultrasonic HC-SR04 sensor. The project is starting with designing the circuit for ultrasonic tracking device.

3.4.1 Block diagram and flowchart of underwater ultrasonic tracking device

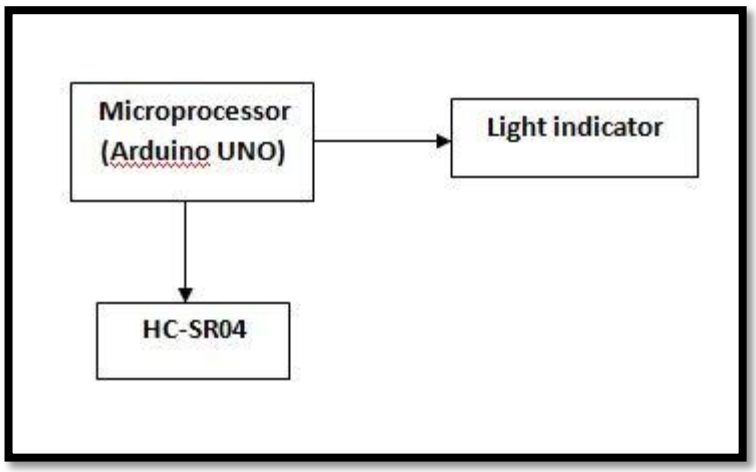


Figure 3.3: Block diagram of underwater ultrasonic tracking device

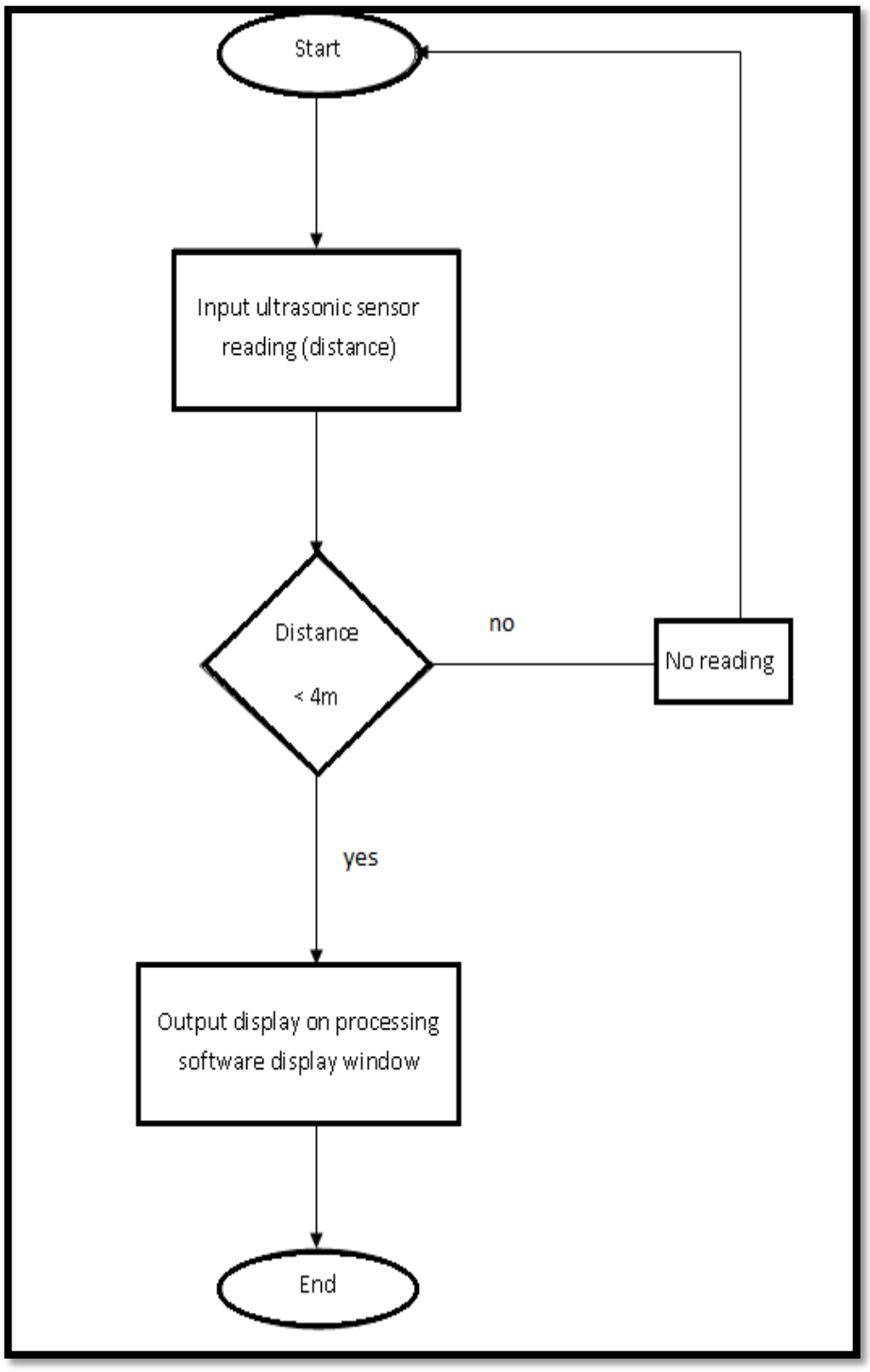


Figure 3.4: Flowchart of underwater ultrasonic tracking device

3.4.2 Main components in the underwater ultrasonic tracking device

. The hardware of this project consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins that can accommodate various extension boards.

Arduino was introduced in 2005. The designer tried to provide an inexpensive and easy way for students, professionals and hobbyists to create devices that interact the environment by using sensors and actuator. It comes with a simple integrated development environment (IDE) that runs on regular personal computers and allows users to write programs for Arduino using C or C++.

3.5 Hardware

3.5.1 Arduino UNO

The Arduino UNO microcontroller is a single board microcontroller. Thus, it is developed to make the beginner or expert easy to build interactive development environments [12].

The Arduino UNO is a microcontroller based on the ATmega328. It consists of 14 digital inputs / output pins, 6 analog inputs, a USB connector, a 16 MHz ceramic resonator, a power jack and a reset button. The Figures 3.5 and 3.6 show the interface of Arduino UNO R3 microcontroller front and back.

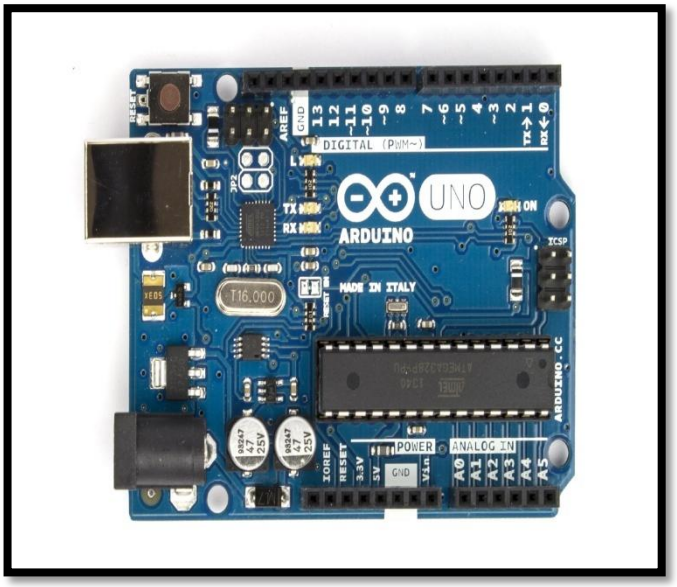


Figure 3.5: The Front Part of Arduino UNO R3

Figure 3.6: The Back Part of Arduino UNO R3

3.5.2 Power

The good thing about Arduino UNO that power can be supplied by using a USB connection comes from the laptop or external power supply from AC-DC adapter or battery. The specification of external power supply or battery must be followed the Arduino UNO power's jack on the board which is about 2.1 mm center-positive plug. Lastly, the connection of battery must be plug into the Gnd and Vin pins[13]. The power pins are stated as follows:

Table 1: Power Pins of Arduino Board

Type of Pins	Description
Vin	The input voltage to the Arduino board which is it opposed to 5v from the USB connection or other regulated power source
5V	This pin outputs a regulated 5V from the regulator on the board.
3v3	A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA
GND	Ground pins
IOREF	This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

3.5.3 Memory Organization

Basically, an Arduino UNO microcontroller use ATmega328. The ATmega328 has 32 KB. It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). Figure 3.7 shows ATmega328 pin out.

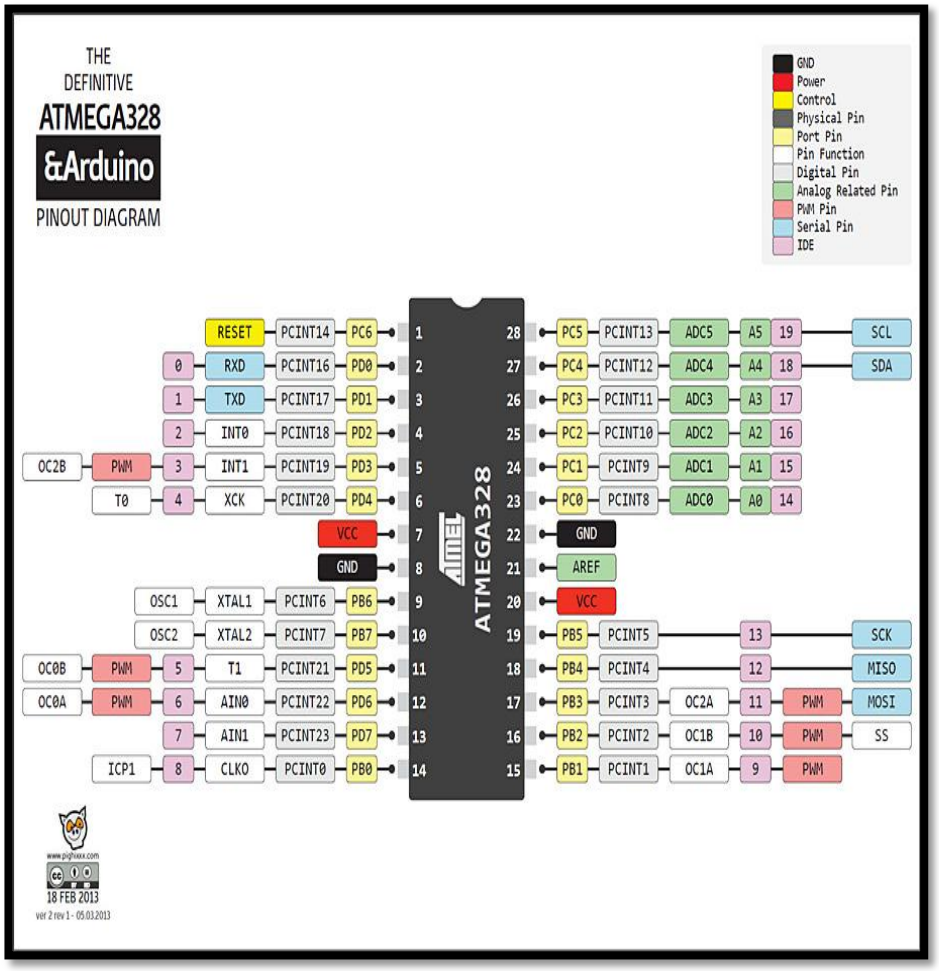


Figure 3.7: ATmega328 Pin out Diagram

PARAMETERS	VALUE
Flash	32 Kbytes
RAM	2 Kbytes
Pin Count	28
Max. Operating Frequency	20 MHz
CPU	8-bit AVR
# of Touch Channels	16
Hardware QTouch Acquisition	No
Max I/O Pins	26
Ext Interrupts	24
USB Interface	No
USB Speed	No

Figure 3.8: ATmega328 Key Parameter

3.5.4 HC-SR04

The HC-SR04 ultrasonic sensor use ultrasound waves to determine the distance of an obstacle / object in front of it such as bat vision or dolphins. The feature of this non-contact sensor is come with a high accuracy and stable readings in an easy to use package. The object must be placed in a minimum range of distance around 2 cm and the maximum distance is 400 cm or 1" up to 13 " away. It does not affected by the sunlight or black material like sharp rangefinders. Basically, a soft material like cloth is difficult to detect. It comes complete with ultrasonic transmitter and receiver module.

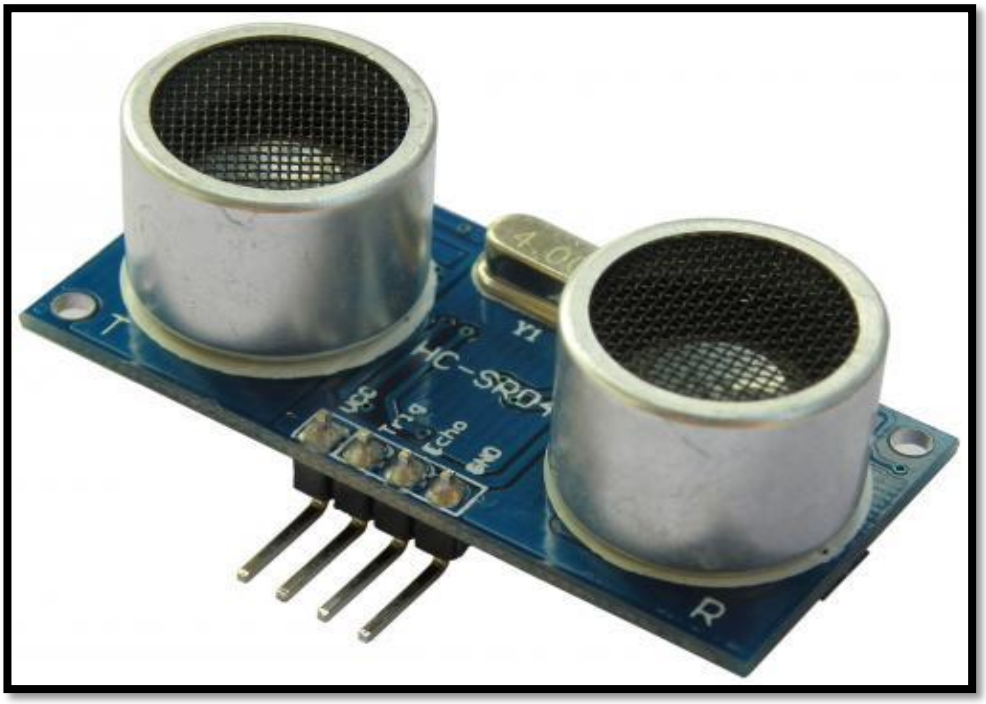


Figure 3.9: HC-SR04

Features:

Power Supply	: +5V DC
Quiescent Current	: <2mA
Working Current	: 15mA
Effectual Angle	: <15°
Ranging Distance	: 2cm – 400 cm/1" - 13ft
Resolution	: 0.3 cm
Measuring Angle	: 30 degree
Trigger Input Pulse width	: 10uS
Dimension	: 45mm x 20mm x 15mm

3.5.5 Basic Principle

HC-SR04 ultrasonic sensor transmitter emits the signal in one direction while the time start to be calculated immediately. Ultrasonic waves will be dispersed in the air and the signal will be come back after hit the object or any particles in front of it. Lastly, the ultrasonic receiver will stop the timing immediately after receives the reflected waves.

The ultrasonic waves has a velocity of sound about 340 m/s in air based on the recorded time t. the time travel was taken between the transmitter to the distance of the object. The formula of velocity of sound is s = 340t / 2. Those are known as time difference distance measurement principle. This principle is related to the measuring the time beginning from the emitting to the reflection of the signal when hit the object or obstacle. The calculation based on the time and velocity of the barrier and transmitter signal. Thus, the principle of ultrasonic distance measurement is the same with radar [14].

The following are the ultrasonic distance measurement formula:

L = C x T

L - The measured distance

C - The ultrasonic spreading velocity in the air

T - Time (T is half the time of a transmitter to receive)

The ultrasonic sensor HC-SR04 is using a time of flight as measurement of the properties of acoustic waves. it also known as "echo ranging" in the reflection mode. A short burst of sound will be emitted by ultrasonic transmitter in a particular direction. The pulse bounces off a target and return back after a time interval **t**. The receiver records the length of this time interval, and calculates the distance travelled **r** based on the speed of sound **c**:

r = c * t

Figure 3.10 shows sound emitted by emitter and reflected back to the receiver as calculated using the above formula.

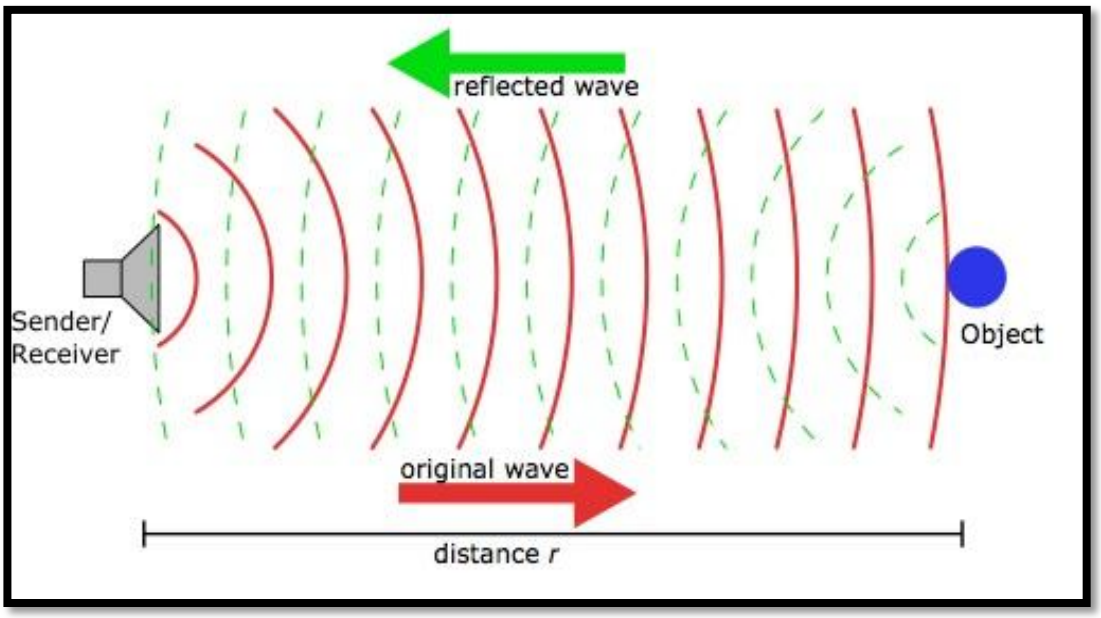


Figure 3.10: The movement of sound wave after reach the object

Basically, the transmitting and receiving transducers are placed next to each other with housed as a single unit. In these cases, the distance calculated will be twice the distance from the sensor to the target.

A single transducer can be used for both emitting the pulse and receiving the echo. For additional information, it takes time for the transducer to change modes, presenting a challenge to short-distance measurement.

3.5.6 Pin Configuration

The following are the pins provided on the HC-SR04:

- VCC = +5VDC
- Trig = Trigger input of Sensor
- Echo = Echo output of Sensor
- GND = Ground

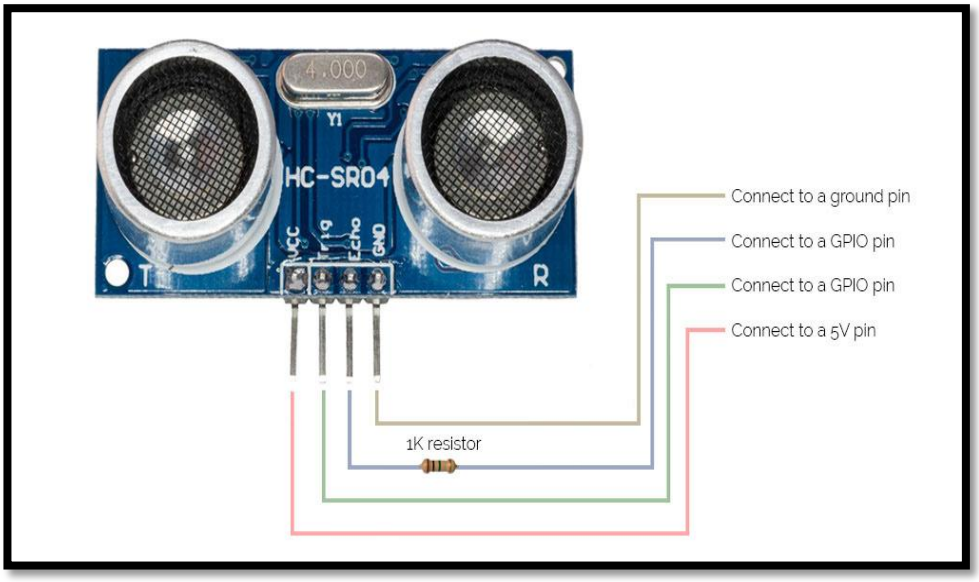


Figure 3.11: HC-SR04 Pin Configuration

3.5.7 Operation

Figure 3.12 shows the time diagram for HC-SR04 ultrasonic sensor. This type of sensor measure a pulse when HC-SR04 received a high pulse which is 5v equals to 10 us. The ultrasonic sensor will be sent out 8 cycle of pulse at 40 kHz. It will delay for a moment so that the ultrasonic sensor will received back the echo signal with a high input 5v. The following are the way how to measure the width of Echo pin and to obtain the distance:

Time = Width of Echo pulse, in uS (micro second)

- Distance in centimeters = Time / 58
- Distance in inches = Time / 148

Or the speed of sound, which is 340m/s

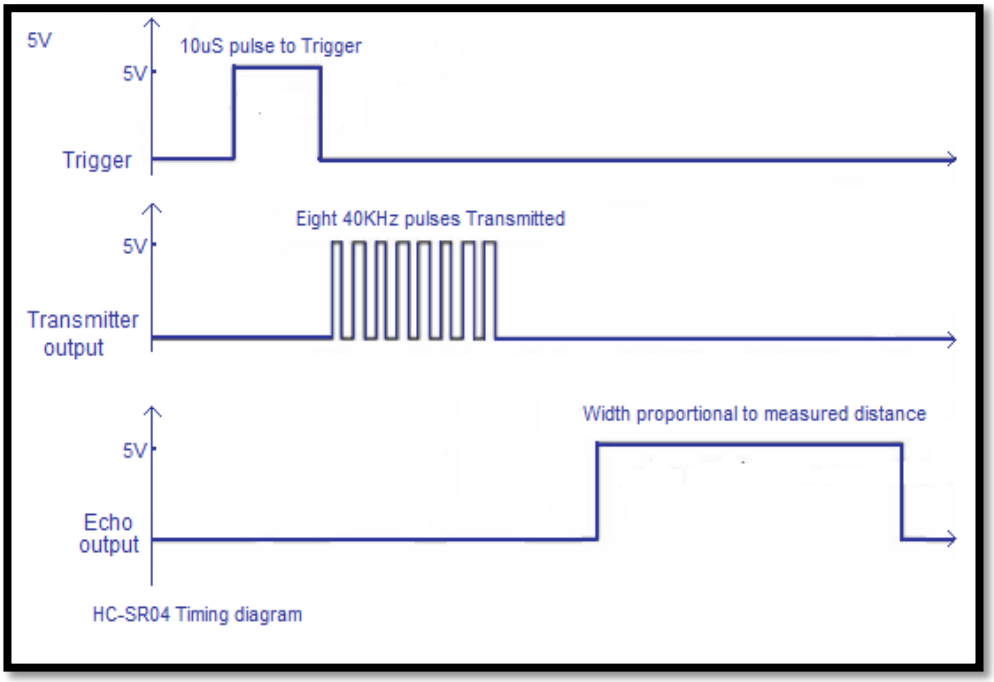


Figure 3.12: HC-SR04 Timing Diagram

3.5.8 Power HD 3001HB servo motor

Power HD 3001HB Servo Motor

The power HD 3001HB servo motor is used to move the ultrasonic servo within a rangeof degree from 45° until 135°. The figure 15 below shows the wire connection of the power HD 3001 servo motor.

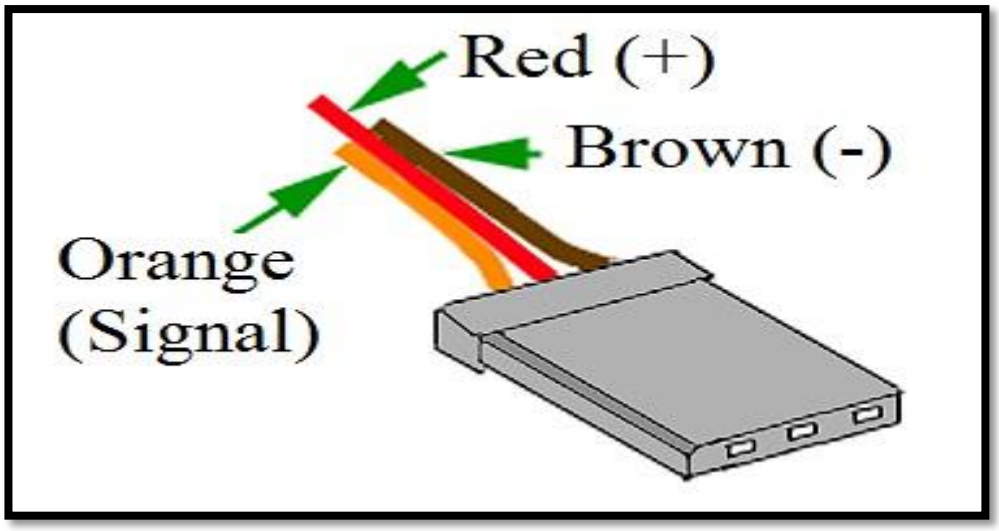


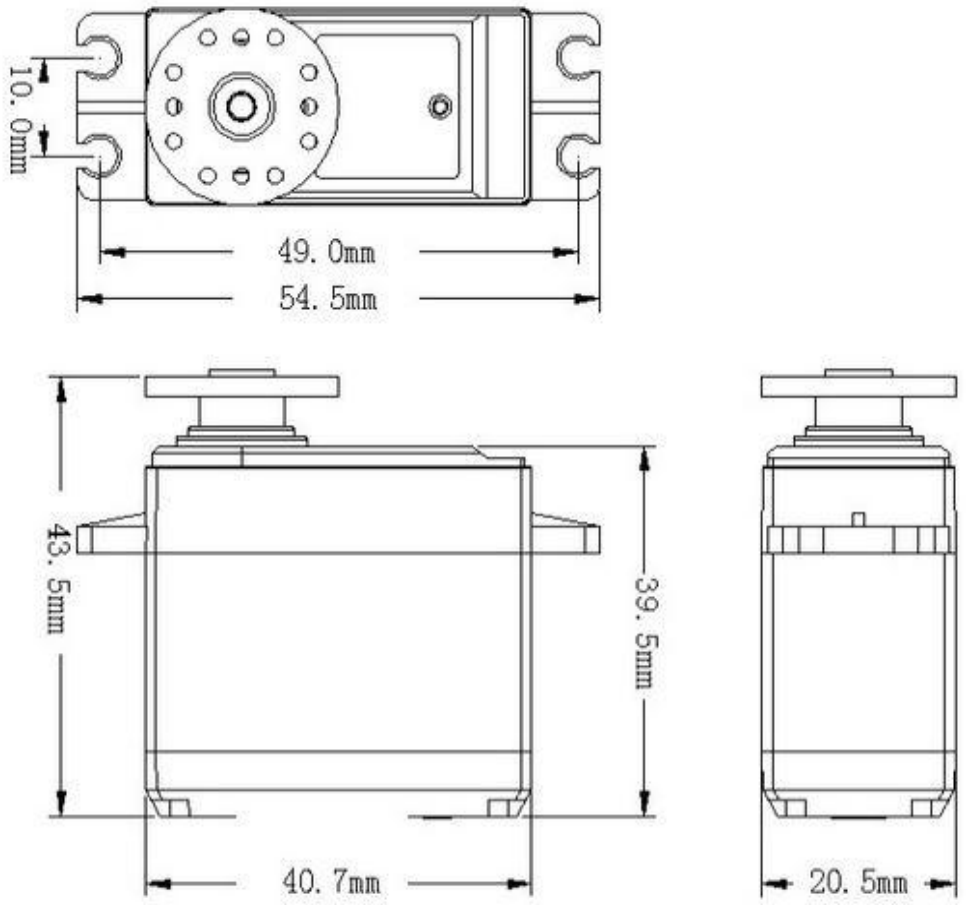
Figure 3.13: The wire connection

This type of servo motor has been used because of their specification which is it made of plastic gear RC with 4.4kg.cm holding torque. Based on the project, it is capable to hold the sensor housing to make it moveable. This type of servo is RC servo motor. RC servo motor is a radio control which is converted electric from the receiver back into movement and simply plug into a specific receiver channel. The movement meaning that the servo will be only moving as much as the transmitter stick on the device is moved. One of the advantage by using RC servo is the DC brush motor is able to control its rotation angle. The following are the specifications of the power HD 3001HB servo motor.

Table 2: The specification of servo motor

Size	40.7 x 20.5 x 39.5mm
Weight	43g
Digital/Analog	Analog
Speed @ 6V	0.12 sec/60°
Stall Torque @6V	4.4kg/cm
Speed @ 6V	0.15 sec/60°
Stall Torque @6V	3.5kg/cm
Lead Length	11in (279.4mm)
Hardware Included	Yes

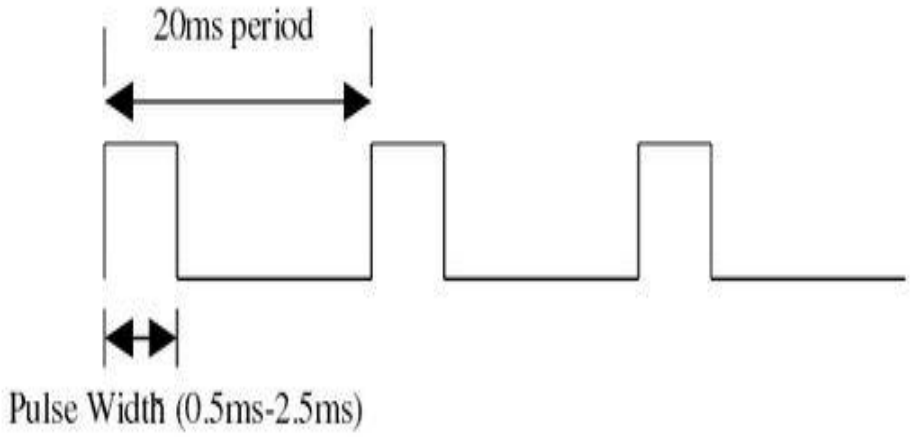
3.5.9 The dimension of the power HD 3001HB servo motor



The Dimension of the Power HD 3001HB Servo Motor

3.5.10 Power HD 3001HB working's principle

The servo motors are controlled by sending it a pulse of variable width by using a signal wire. The parameter can be classified into three which is a repetition rate, minimum pulse and maximum pulse. As the servo has its constraint in rotational, the neutral position can be defined as the position where the servo has a same value of potential rotation in the clockwise direction as it does in the counter clockwise direction. For additional information, every types of servo motor will have their own different constraints on their rotational.



This servo motor is used a Pulse Width Modulation (PWM) which is the angle of servo motor is determined by the duration of a pulse that is applied to the signal wire. In every 20 ms the servo is expected to see a pulse sent to them. The length of the pulse will be determined by motor turning which is how far it turns. However, the exact correspondence between pulse width and servo varies from one servo manufacturer to another. The pulse of 1.5 ms is not an exact value to stay in neutral or middle position[15].

3.6 Software implementation

Software implementation is designing a suitable algorithm to calculate distance for detecting object in the limited region. To program the code of this underwater ultrasonic tracking device, it must use the Arduino software version 1.5.4 and Processing software version 2.2.1. The code which is used in Aduino and Processing software programming based on C++ programming.

3.6.1 Processing Software

Basically, processing is related to the software concept to the principle of visual concepts, interaction and movement. It is also the integration of a

programming language environment, development, and teaching methods into a unified system. Processing was created for processing fundamentals of computer programming within the context of visual and also as a software sketchbook. Besides that, it is also used as prototype manufacturing, an output and production.

The processing language is specifically designed to generate and modify images especially for this project. It can be achieved the clarity and advanced features. All the beginners can write their own programs and the advanced user also can employ and write libraries with additional function. The system provides many computer graphics and interaction techniques including image processing, vector drawing, colour models, mouse and keyboard events, object-oriented programming and network communication,. The libraries are capable to generate sound, send/receive data in diverse formats, and to import or export 2D and 3D file formats [16].

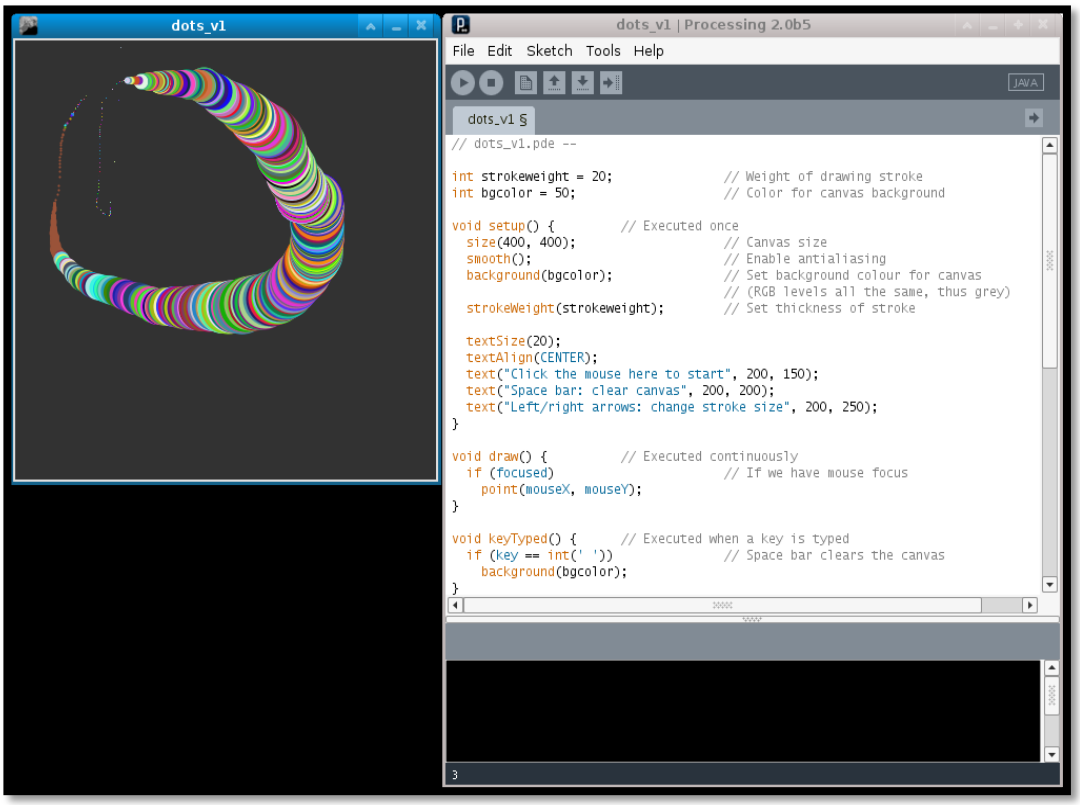

dots_v1
dots_v1 | Processing 2.0b5
File Edit Sketch Tools Help
JAVA
dots_v1 §
// dots_v1.pde --
int strokeweight = 20; // Weight of drawing stroke
int bgcolor = 50; // Color for canvas background
void setup() { // Executed once
size(400, 400); // Canvas size
smooth(); // Enable antialiasing
background(bgcolor); // Set background colour for canvas
// (RGB levels all the same, thus grey)
strokeWeight(strokeweight); // Set thickness of stroke
textSize(20);
textAlign(CENTER);
text("Click the mouse here to start", 200, 150);
text("Space bar: clear canvas", 200, 200);
text("Left/right arrows: change stroke size", 200, 250);
}
void draw() { // Executed continuously
if (focused) // If we have mouse focus
point(mouseX, mouseY);
}
void keyTyped() { // Executed when a key is typed
if (key == int(' ')) // Space bar clears the canvas
background(bgcolor);
}
3

Figure 3.14: Processing Display Window

3.6.2 Processing Development Environment (PDE)

The processing development environment (PDE) is a programming languages, online community and development environment. The processing development environment (PDE) consists of a text console, a message area, a text editor writing code, tabs for managing files, a series of menus and a toolbar with buttons for common actions. It will show a display window when running the program. The Figure 3.15 shows the PDE display window.

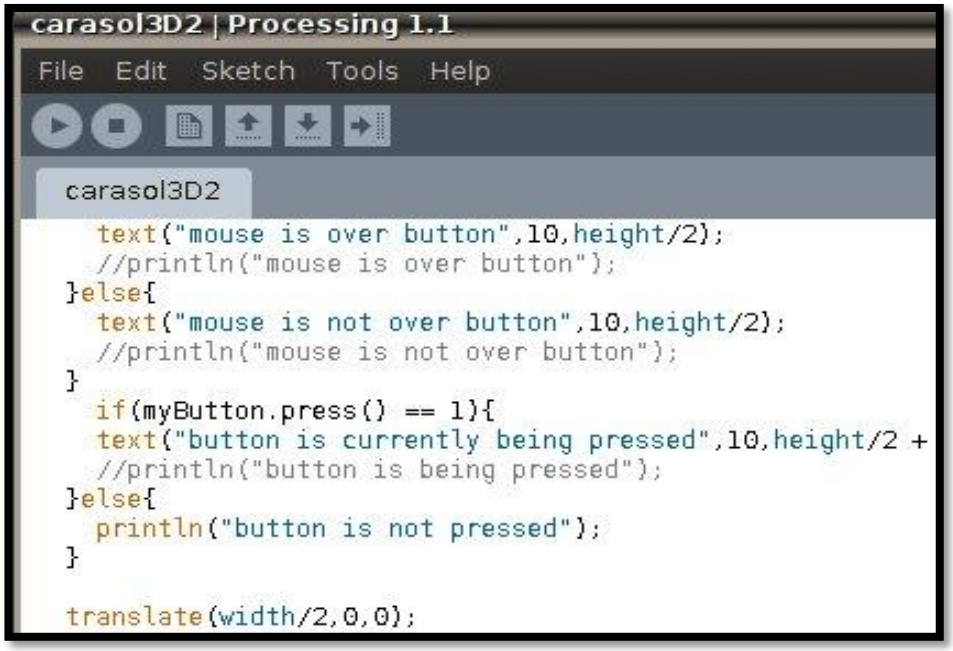


Figure 3.15: Processing Development Environment Display Window

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Chapter four is about the experiments carried out to get the result. The experiment is the limitation of ultrasonic sensor and to display the object position at the processing display window.

4.2 Tracking system

4.2.1 Experimental in air

The ultrasonic HC-SR04 was used to detect the object or obstacle in the free space (air). As additional information, when ultrasonic sensor sent the signal from transmitter to the barrier, the echo will be reflected back to the receiver so that it will convert to the image processing to view the obstacle's position. The signal's frequency sent by transmitter is 40 kHz. So it is able to go through air easily. Then the data will be recorded on the screen based on the distance away from the object and also the degrees of rotational. Figure 18 shows an object detected due to signal bounce back to the receiver.

The distance between the obstacle and ultrasonic sensor in can be determined by using the formula distance=time/58. It also shows the degree of rotation for each

distance sensed by ultrasonic due to the rotation of servo motor within the ranges of 45° until 135° by using the formula angle = float(Theta) /180 * pi.

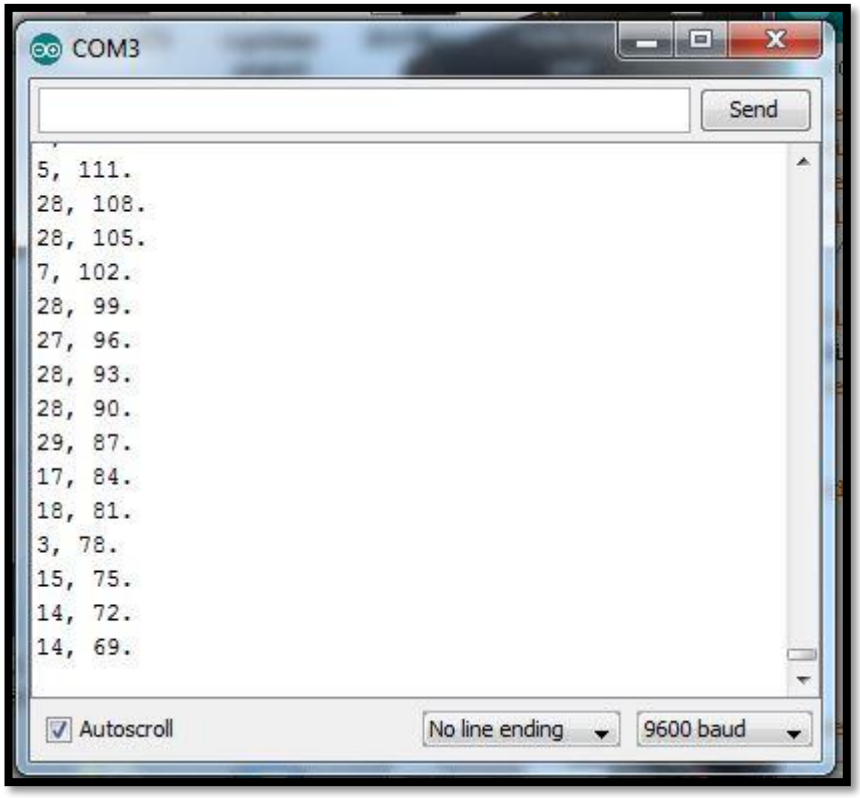


Figure 4.1: The data recorded based on the distance of object in the air

Table 3: Result of sensor detected and measures distance

Distance Measurement (cm)	Sensor Detected (cm)
5	**5**
10	**10**
15	**15**
20	**20**
25	**25**

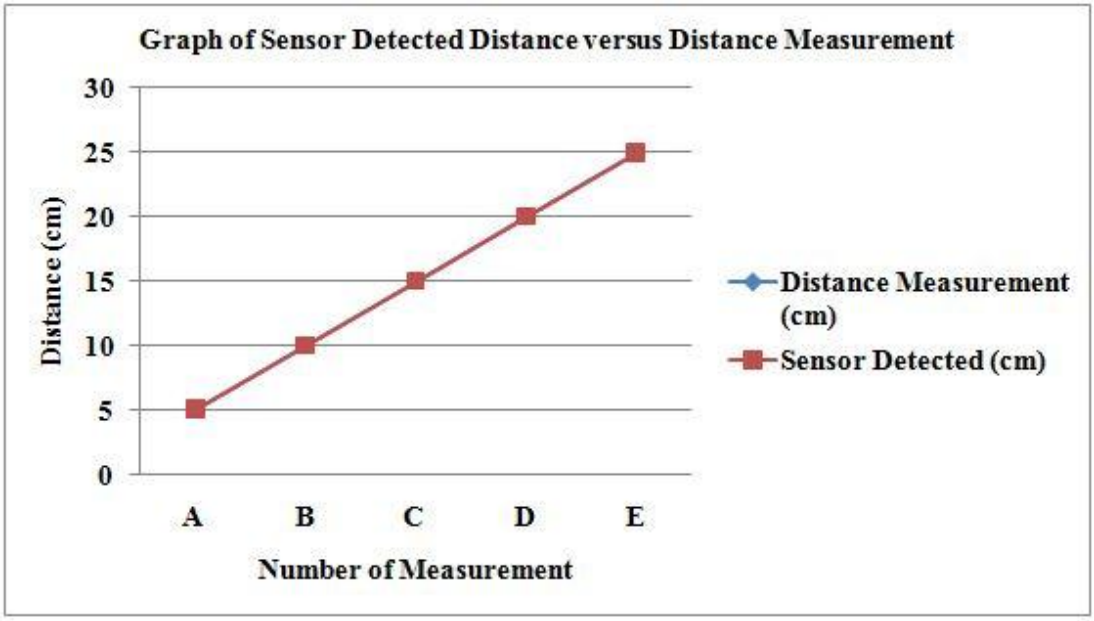


Figure 4.2: Graph of sensor detected distance vs distance measures

Table 3 and Figure 4.2 show the differences between ultrasonic sensor measurement and the actual measurement between the object and ultrasonic sensor. There are no error between the result of ultrasonic sensor and measured values because of ultrasonic transmit signal in the air is smooth. This project is limited by the frequency of ultrasonic sensor and the low cost of material. Hence, it only shows the transmitted signal with a limited range of distance and the value is reliable.

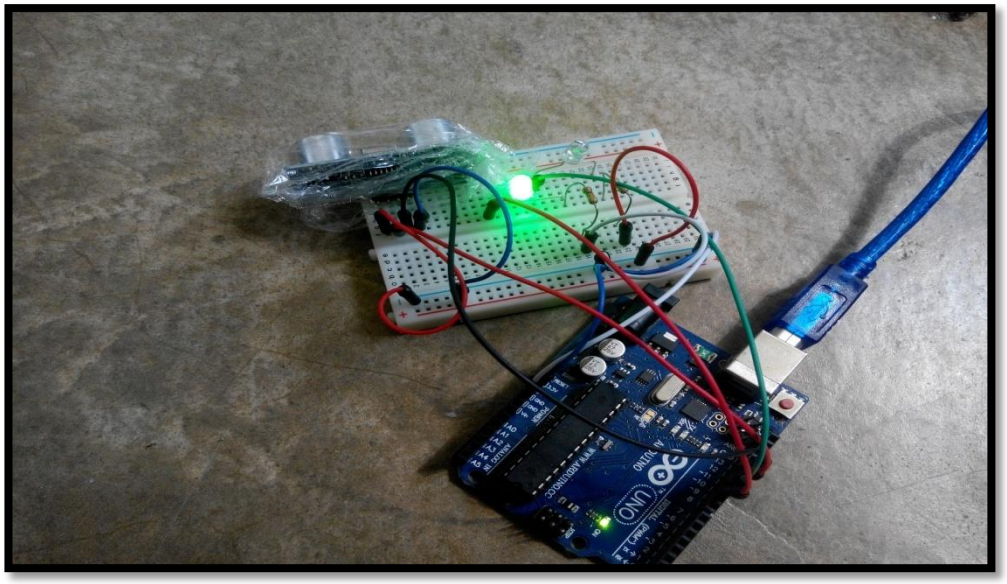
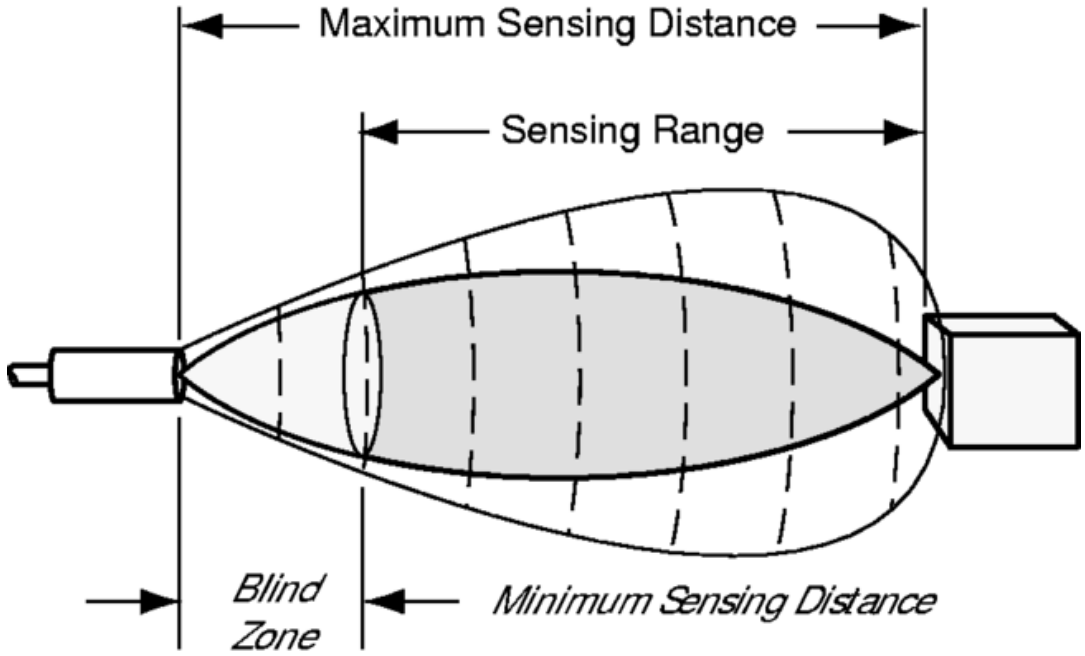


Figure 4.3: Hardware implementation (HC-SR04 sensor) for tracking system

Figure 4.3 shows the hardware implementation of a tracking system. The ultrasonic sensor was designed to be waterproof. The element being used was food wrapping as a cover of ultrasonic transmitter and receiver. This is due to the dead zone of ultrasonic sensor. Dead zone can be called as blind zone. Basically, ultrasonic sensor have a "dead zone" in front of them which is the object cannot be detected by transmitter signal. This is because they deflected the wave back before the receiver signal is operational. In other word, the resonance from the transmitter signal is force the receiver signal to pause a moment before starting to listen for the echo.

The LED on the above picture show that the ultrasonic HC-SR04 sensor working on the food wrapping. Even though the transmitter and receiver are both were cover by food wrapping but the signal still can be transmit and receive since the object in front of it. The following are the dead / blind zone of ultrasonic sensor.



4.2.2 Experimental in water

Sound waves are one of the compression wave based on the audible spectrum. As human being, we are only using a range of frequency about 20 Hz up to 20 kHz. Besides that, marine life has their own range of frequency which is more than 20 kHz. Sound outside the human hearing range of frequencies also known as infrasound which is below 20 Hz and ultrasound which is above 20 kHz [17].

This experimental was carried out by immersing the ultrasonic HC-SR04 covering with food wrapping into the water. As a result, a food wrapping can withstand with the water and there is no leaking either at the food wrapping or housing. The Figure 4.4 shows that hardware implementation for housing.

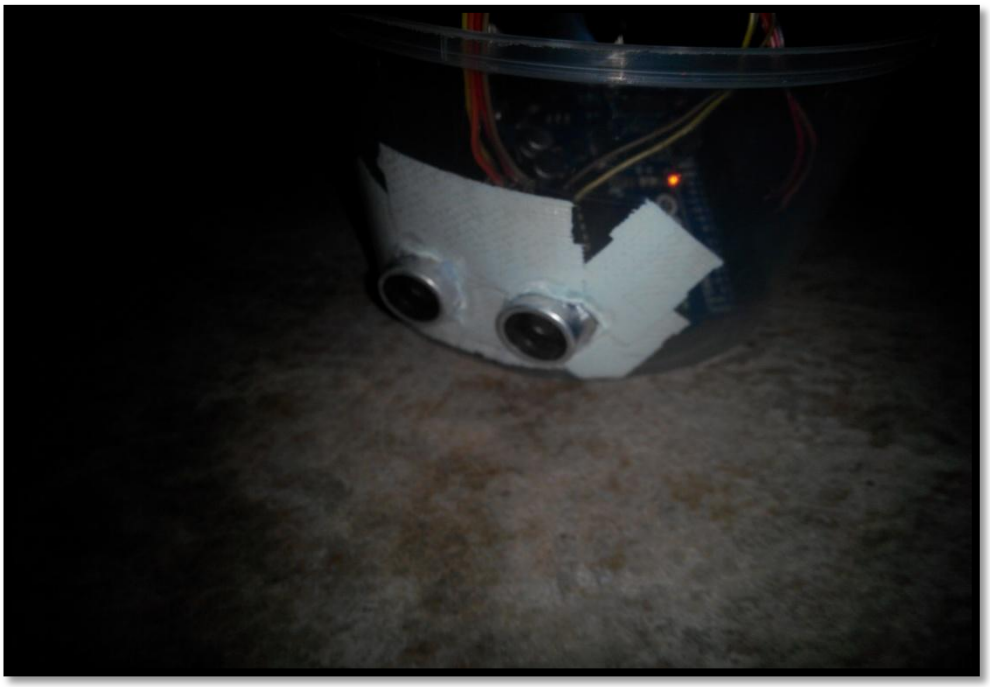


Figure 4.4: Hardware implementation for housing

The housing made up from an environmental casing. This is due to the rusting factor. An environmental casing is one way to reduce the environment pollution and also it can be used for many times. For the first attempt to make housing, perspex was choose because of the endurance is high quality but at the same time it is difficult to produce. In additional, the project is focus more to the low cost

material and environmental aspect. The Figure 4.5 shows the housing made up from prespex.

This type of housing still cannot achieve the requirement because of leakage in the housing. The prespex was glued with a hot glue gun so that the water cannot pass through the housing. The first attempt was failed and it needs to be re-do by using others alternative. It also gives an effect to the reading of ultrasonic HC-SR04 sensor to emit the signal because the glue was scattered and close the transmitter and receiver. The reading of distance is not achieves the consistence value.

Figure 4.5: Hardware implementation for first attempt

The Figure 4.6 shows the processing display window is detecting an object inside the water. The signal transmitted by the transmitter is not get an exact value due to the low frequency of ultrasonic HC-SR04 sensor. It happens only in the water due to the different propagation paths. The transmitted / reflected signal will not have same characteristics as a pulse near the signal source. An elongated pulse from seismic sources is often occurs at a long distances when transmission / reflection process happen.

The object detection is only placed on the centre of the image because the signal has its limitation inside the water by using this type of sensor. Based on the

datasheet of HC-SR04 ultrasonic sensor, the frequency of ultrasound is fixed to 40 kHz. The sensor is unable to increase the voltage due to the fixed voltage. In theory, the power of signal transmitted can be increase and it possible to penetrate the solid medium by amplified the voltage supplier.

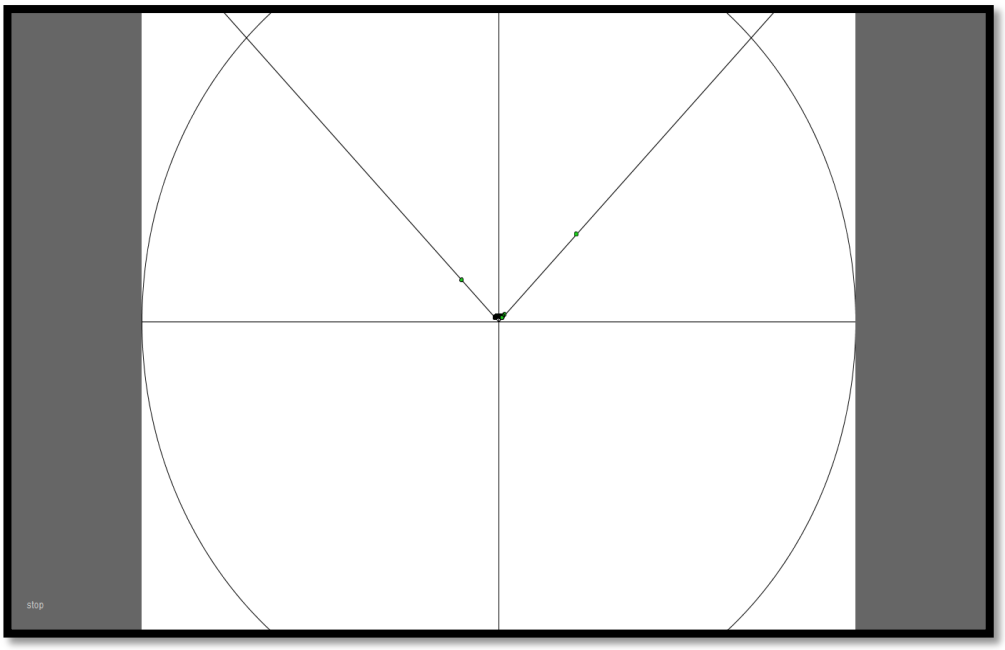


Figure 4.6: The processing display window showing the detection object

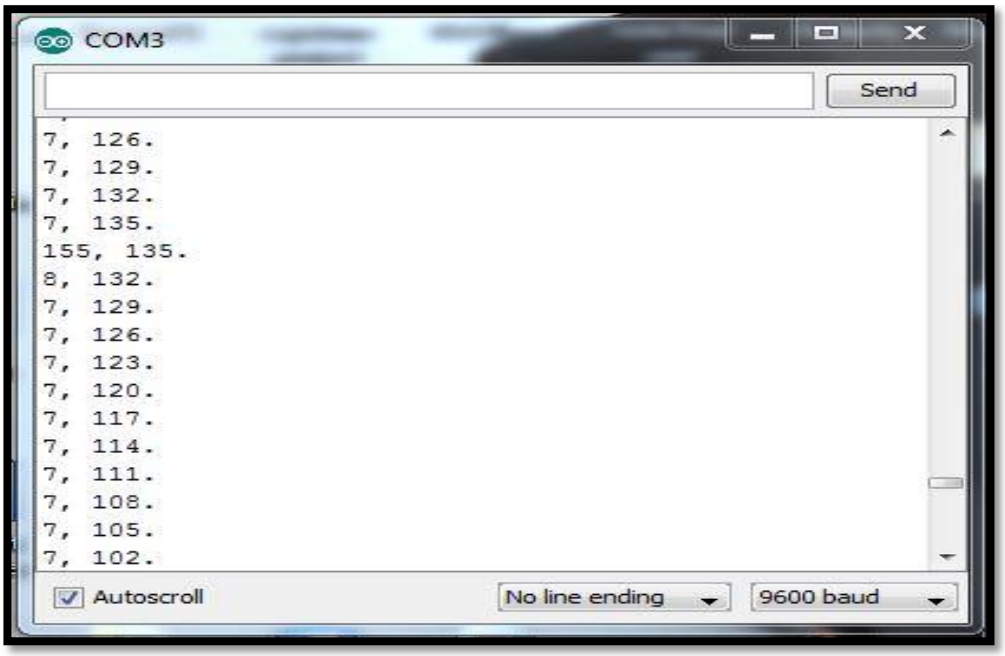


Figure 4.7: The distance value of ultrasonic sensor

Figure 4.7 shows the limitation of ultrasonic sensor when the signal is transmitted but with a short range of distance. This is because the coding of ultrasonic sensor has been changed. The formula of speed of sound is not exactly like the datasheet's formula but the constant value of the formula was changed to get the real value. The exact speed of sound formula:

Distance = distance1 / 58

As additional information, the wavelength of a sound between air and water is equal. It can be divided into two types of sound wave which is 20 KHz where 75 m long in the water and 20 Hz where 17 m long in the air.

The formula being used as shown below:

Distance = distance1 / 1500

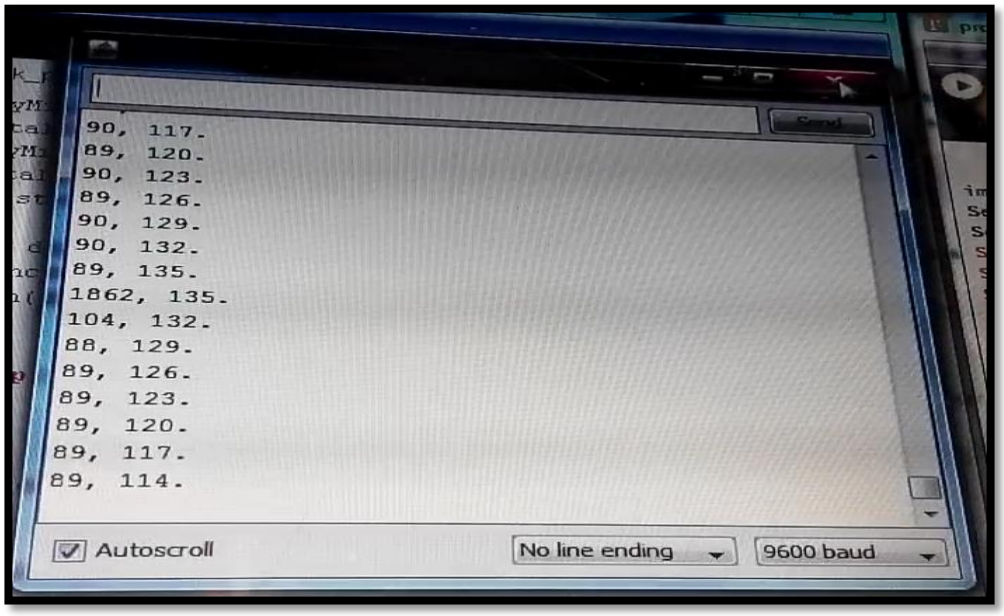


Figure 4.8: The value of distance before calibrating the resolution

The Figure 4.8 above shows the resolution before calibration. The resolution of distance is too high because of the smallest change of constant value in the speed of sound formula. By putting a large number of constant values so that the resolutionbecome smaller as shown in figure 24.

Figure 4.9 and table 4 shows the result between reference object and output value. There are some errors between the result of ultrasonic sensor and measured values due to the low frequency of the ultrasonic sensor. The errors happen because of the inhomogeneous waves. The phenomena cause the energy transfer with a low frequency. The cases showing itself with the increasing of energy flux and decreasing the frequency of sound[18].

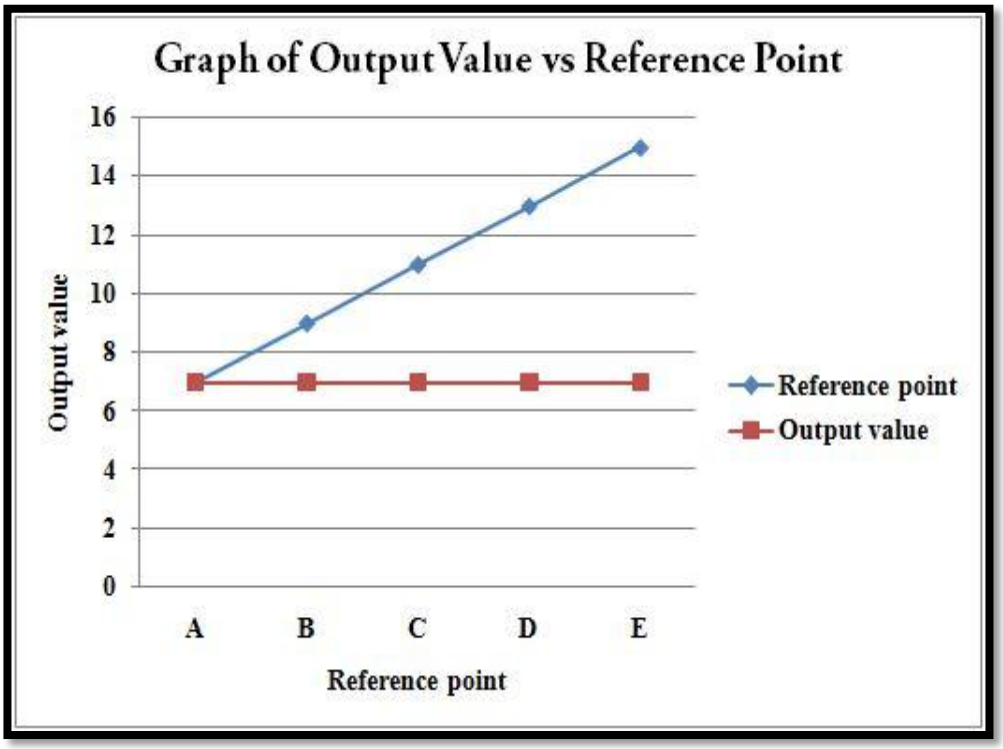


Figure 4.9: Graph of output value vs reference point

Table 4: The result of reference point and output value

Reference point (cm)	Output value (cm)
7	**7**
9	**7**
11	**7**
13	**7**
15	**7**

4.2.3 Rotational system

The energy of electromagnetic wave will be slowed down when it pass through into the water. This is because the ability of the sound wave has a limited range of distance. This is happen when the signal inferred each other. To get the exact value, they must use a special specification of the underwater sound waves equipment.

As an alternative way, the rotational of the project is limited from 45° until 135°. The first attempt was to put some degree so that the ultrasonic sensor can detect the object inside the water. In theory, the movement of water give an effect to the signal of ultrasonic sensor due to the particles of water itself does not synchronise each other. The Figure 4.10 shows that the rotational ultrasonic sensor with a smooth water propagation.

Figure 4.10: The rotation of ultrasonic sensor in the water

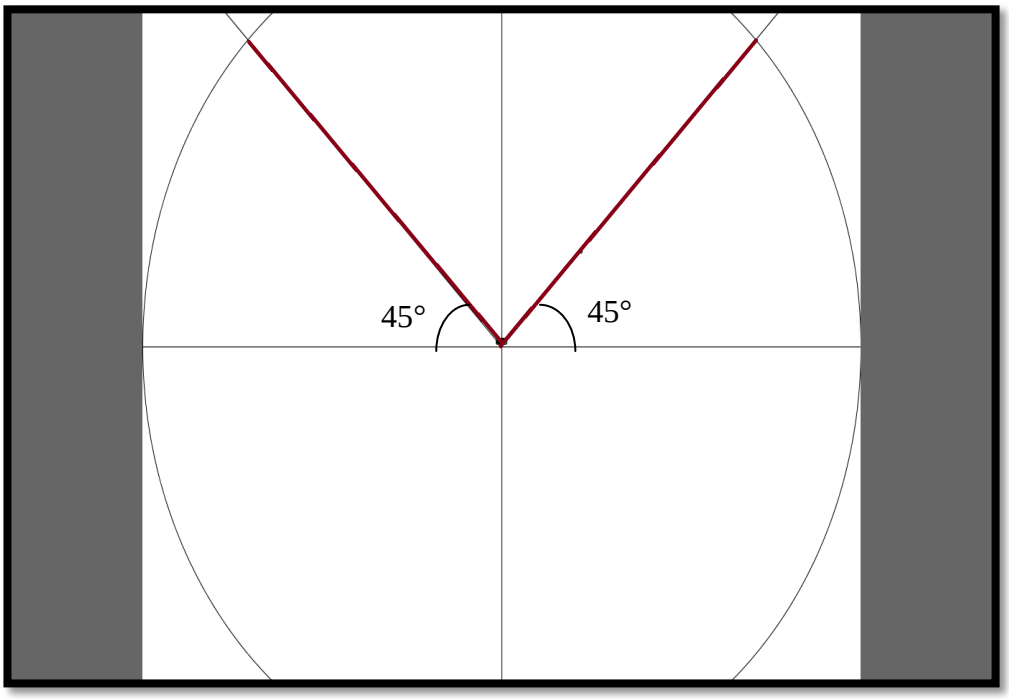


Figure 4.11: The limitation of servo motor

Figure 4.11 shows that the limitation of servo motor can be implemented in this project. The red line is the showing that 45° until 135°. So the object detection image will be display within a range of the limitation only.

4.3 Overall system design

Figure 4.12 shows the schematic diagram of this project. HC-SR04 ultrasonic sensor, the connection of digital input Port 8 is for trigger pin while digital input port 7 is for echo respectively. The connection of the servo motor is at the digital input port 9.

Figure 4.13 shows the overall hardware of circuit diagram. The ultrasonic sensor and servo motor are connected to the Arduino UNO.

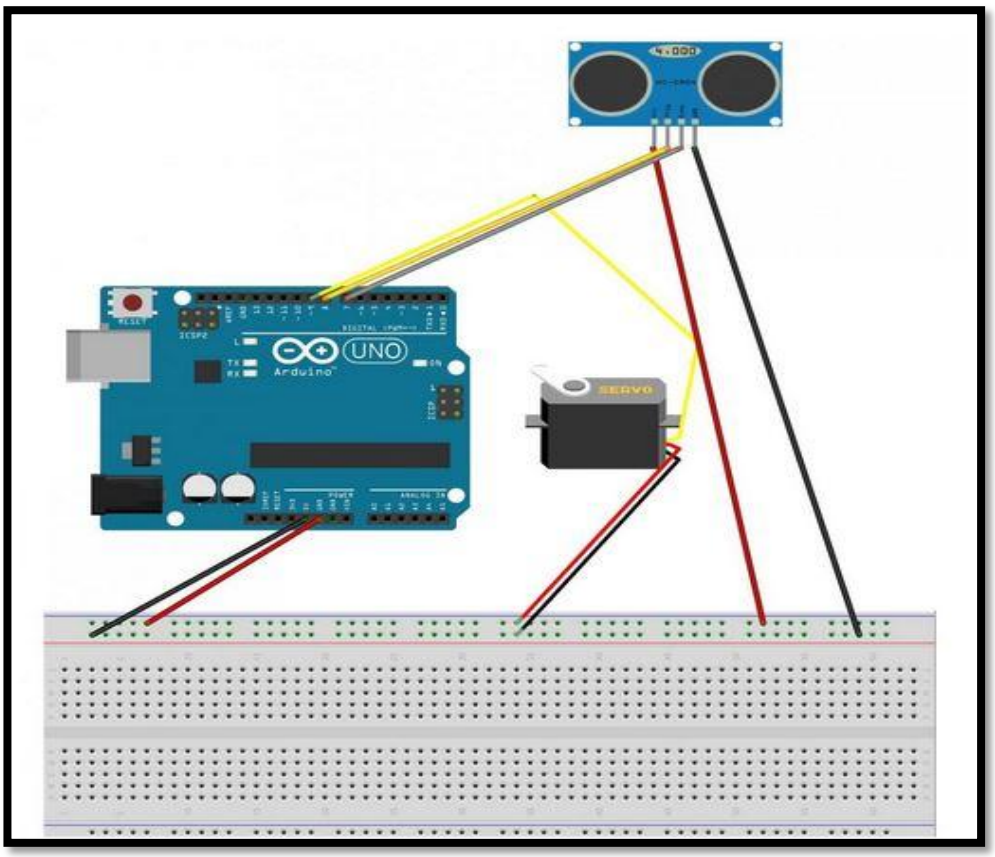


Figure 4.12: Schematic diagram of project

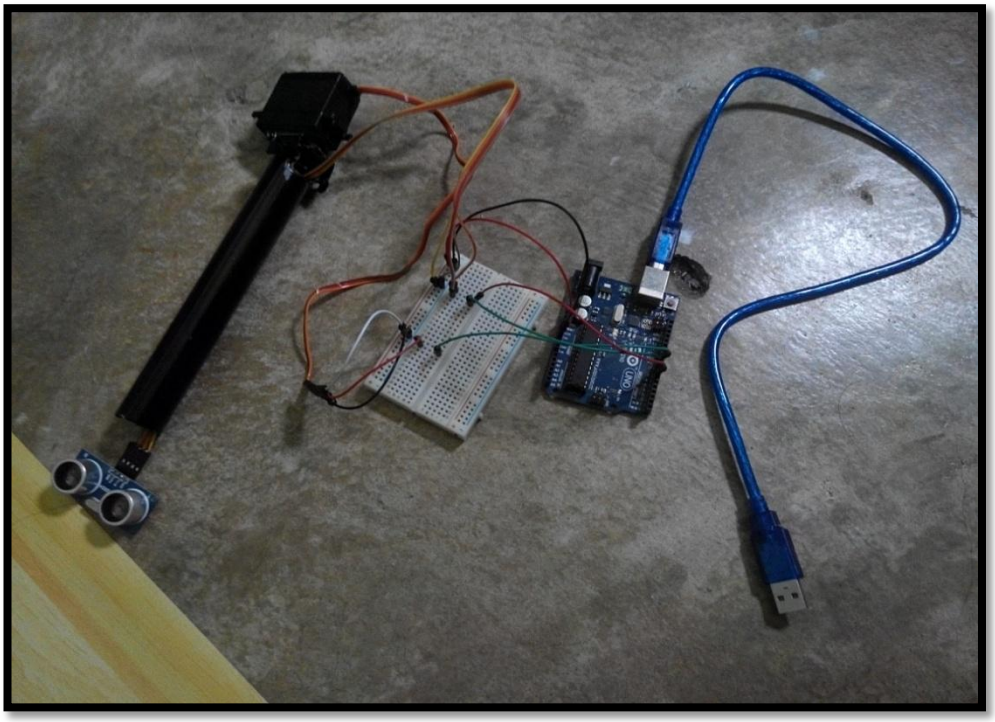


Figure 4.13: The overall hardware of circuit diagram

Figure 4.14 shows the prototype of an underwater ultrasonic tracking device. The prototype is built using PVC pipe and Tupperware as a low cost material. Lower part of the PVC pipe consists of ultrasonic HC-SR04 with housing. Upper part consists of Arduino UNO, servo motor and circuit with housing.

Figure 4.14: Overall hardware design

CHAPTER 5

CONCLUSION

5.1 Introduction

Chapter five concludes the whole project of an ultrasonic underwater tracking device. Several recommendations for the future work are stated as well.

5.2 Conclusion

As a conclusion, the projectincludes the combination of ultrasonic sensor, servo motor, and Arduino UNO R3 for tracking object in the water. The development environment consists of two types which are Arduino IDE and Processing (PDE). Two main objectives which isto find object in the water and to display the position of an object by using a processing software is successfully implemented even though the signal of ultrasonic sensor did not get exact value which is the range of signal transmitted is around 7 cm.

The hardware and software of the project had been successfully implemented andworked as the requirements. The prototype of an underwater ultrasonic tracking device is built and the function meets some of the objectives of this project.

5.3 Future work

Several future planning are suggested and recommended so that the project can be improved. The accuracy of the obstacle detection can be increased. Therefore, the frequency of the ultrasonic sensor must be higher than frequency of water and the rotational of servo motor should be improved. The servo motor can be adjusted to detect fast moving objects. Moreover, the degree of rotational can be increase to 360°.

The processing image can be improved by putting a distance of object's detection. The ultrasonic sensorshould be able to capture distance precisely.

CHAPTER 6

PROJECT MANAGEMENT

6.1 Introduction

The project management is very important as a smoothness of the project planning. It is consists of the overall planning control and coordination of a project, from inception through to completion. The process is about the responsibilities for all phase of a project. They are combined all the phase within one multi-disciplinary function[19].

6.1.1 Project schedule

The Figure 6.1 shows the Gantt chart for both semester 1 and semester 2. For semester 1, the project is focus on the research of the fabrication. Ultrasonic sensor and servo motor are studied to get the function and design. For semester 2, the project is focus on the programming on tracking system including IDE and PDE. After that, the circuit for the design is built up. The prototype of a project needs to test and calibrate to ensure the requirement achieve the objective.

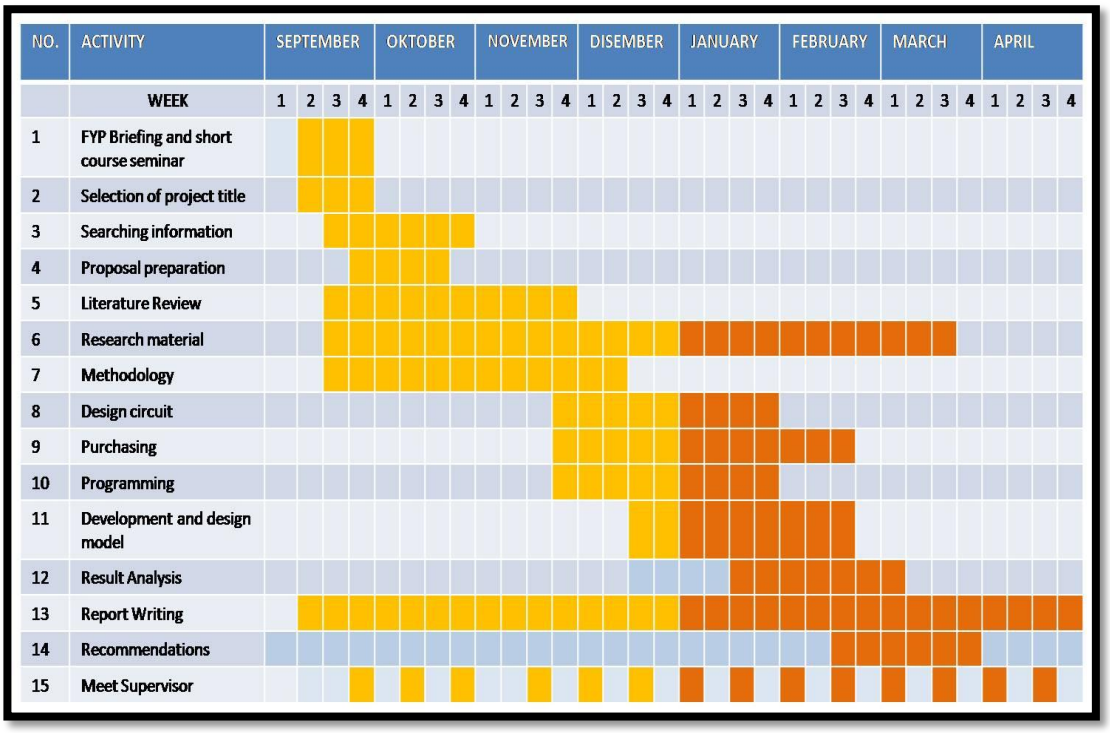


Figure 6.1: Gantt chart

6.1.2 Cost Estimation

Table 5 shows the cost estimation of the project. The cost includes the hardware materials consist of Arduino UNO, breadboard, jumper, Tupperware casing, PVC, servo motor and ultrasonic.

Table 5: Project Budget

ITEM	PRICE (RM)
Arduino UNO	40.00
Breadboard	7.90
jumper	Available
Tupperware casing	Available
PVC	Available
Servo Motor	39.00
Ultrasonic HC-SR04	39.00
TOTAL	**125.90**

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APPENDIX A

Tracking System Coding

```
#define ECHOPIN 7        // Pin to receive echo pulse
#define TRIGPIN 8
#include <Servo.h>

Servo myservo; // create servo object to control a servo
intpos = 0; // variable to store the servo position
void setup()

{
Serial.begin(9600);

myservo.attach(9); // attaches the servo on pin 9 to the servo object
pinMode(3,OUTPUT);
pinMode(12,OUTPUT);
pinMode(13,INPUT);
pinMode(ECHOPIN, INPUT);
pinMode(TRIGPIN, OUTPUT);
}

void Print (int R , int T)
{
Serial.print(R);Serial.print(", ");
Serial.print(T);Serial.println(".");
delay(100);
}

float Distance ()

{
```

```
digitalWrite(TRIGPIN, LOW);
delayMicroseconds(2);
digitalWrite(TRIGPIN, HIGH);
delayMicroseconds(10);
digitalWrite(TRIGPIN, LOW);
  // Distance Calculation

float distance = pulseIn(ECHOPIN, HIGH);
distance= distance/1200;
return(distance);
}

void loop()

{
myservo.write(45); // tell servo to go to position in variable 'pos'
delay(2000);
for(pos = 45; pos <= 135; pos += 3) // goes from 45 degrees to 135 degrees
{ // in steps of 1 degree
myservo.write(pos); // tell servo to go to position in variable 'pos'

Print(Distance() , pos);
delay(10); // waits 15ms for the servo to reach the position
  }
delay(1000);
for(pos = 135; pos>= 45; pos-=3) // goes from 135 degrees to 45 degrees
  {
myservo.write(pos); // tell servo to go to position in variable 'pos'
Print(Distance() , pos);

delay(10); // waits 15ms for the servo to reach the position
  }

}
```

APPENDIX B

Image Processing Coding

```
importprocessing.serial.*;
Serial port;
Serial port2;
String data = "";
String Radius = "";
String Theta = "";
int index = 0;
float distance = 0;
float angle = 0;
float pi = 22.0/7;

void setup()
{

size(1000,1000);
background(255,255,255);
ellipse(500,500,1000,1000);
line(500,0,500,1000);
line(0,500,1000,500);
line(500,500,1000,0);
line(500,500,0,0);

port = new Serial(this, "COM3", 9600);
port.bufferUntil('.');
}

void draw()

{
```

```
}

voidserialEvent(Serial port)
{

data = port.readStringUntil('.');
data = data.substring(0, data.length() - 1);
index = data.indexOf(",");
  Radius = data.substring(0, index);
  Theta = data.substring (index+1 ,data.length());

translate(500,500);
point (0,0);

distance = float(Radius);
angle = float(Theta) /180 * pi;
fill(30,200,30);
ellipse(distance * cos(angle) ,  -1 * distance * sin(angle) , 5,5);



}
```